CLAIMS

1. An apparatus for multiple antenna transmitter beamforming M digital output OFDM signals ("M signals") each including sub-carrier data in N frequency bins in a wideband wireless packetized communication network, wherein the M signals are each adapted for transmission onto different communication channels, and wherein each of the M signals are obtained from a same single digital signal , wherein N is a positive integer greater than 1, the apparatus comprising:

a transmit beamformer adapted to phase steer the sub-carrier data in each of the N frequency bins for each of the M signals, thereby generating phase steered frequency data for each of the M signals; and

M Inverse Fast Fourier Transform units (IFFTs) that are each adapted to input the phase steered frequency data for one of the M signals and each convert the phase steered frequency data corresponding to that one M signal to obtain that one M signal, wherein M is an integer greater than or equal to 2, such that the M signals are adapted to shape a distinct array antenna pattern.

2. The apparatus according to claim 1 wherein the transmit beamformer is further adapted to weight the sub-carrier data in each of the N frequency bins for each of the M signals, thereby generating phase steered and weighted frequency data for each of the M signals, and wherein the transmit beamformer includes:

a weight calculator adapted to calculate M complex weights for each of the N frequency bins based on channel estimates of the different communication channels; and

a weighting block adapted to apply the M complex weights to the sub-carrier data corresponding to each of the N frequency bins for each of the M signals to obtain the phase steered and weighted frequency data for each of the M signals; and wherein the M IFFTs are each adapted to input the phase steered and weighted frequency data for one of the M signals and each convert the phase steered and weighted frequency data corresponding to that one M signal to obtain that one M signal.

3. The apparatus according to claim 2 wherein:

the weight calculator, for each of the N frequency bins, converts the channel estimates into corresponding complex weights, thereby obtaining the M complex weights for each of the N frequency bins; and

the weighting block includes M different weight blocks, wherein each weight block applies corresponding complex weights to the sub-carrier data corresponding to one of the M signals to obtain the phase steered and weighted frequency data for that one M signal.

4. The apparatus according to claim 3 wherein the weight calculator further includes using gain data in determining at least certain ones of the complex weights.

5. The apparatus according to claim 2 wherein each IFFT sequentially processes the phase steered and weighted frequency data from each of the N frequency bins for the corresponding M signal.

6. The apparatus according to claim 2 wherein the weight calculator further includes using gain data in determining at least certain ones of the complex weights, and obtains the gain data from a receiver.

7. The apparatus according to claim 6 wherein the transmit beamformer is part of a transmitter, and the receiver and the transmitter share an antenna.

8. The apparatus according to claim 6 wherein the transmit beamformer is part of a transmitter, and the receiver and the transmitter share multiple antennas.

9. The apparatus according to claim 2 wherein the weight calculator obtains the channel estimates from a receiver.

10. The apparatus according to claim 9 wherein the transmit beamformer is part of a transmitter, and the receiver and the transmitter share an antenna.

11. The apparatus according to claim 9 wherein the transmit beamformer is part of a transmitter, and the receiver and the transmitter share multiple antennas.

12. The apparatus according to claim 9 wherein the channel estimates obtained from the receiver are for different channels received over a period of time.

13. The apparatus according to claim 12 wherein the communication channels used correspond to those communication channels for which channel estimates are obtained.

14. The apparatus according to claim 9 wherein the weight calculator obtains the channel estimate for a particular frequency bin for a particular communication channel.

15. The apparatus according to claim 2 wherein at least some of the M complex weights for each of the N frequency bins are spectral flatness weights that assign constant power for each of the N frequency bins, thereby keeping spectral flatness across all of the N frequency bins for at least some of the M signals.

16. The apparatus according to claim 2 wherein at least some of the M complex weights are obtained from gain-adjusted channel estimates and are normalized based upon Effective Isotrophic Radiated Power limit and per-chain power limit..

17. The apparatus according to claim 2 wherein at least one of the M complex weights for each of the N frequency bins is a discretized complex weight having a lower resolution than full resolution.

18. The apparatus according to claim 17 wherein the discretized complex weight is represented by a pair of 3-bit binary numbers.

19. The apparatus according to claim 17 wherein each of the M weight blocks is a 12-bit x 3-bit multiplier.

20. The apparatus according to claim 2 wherein the weight calculator, for each of the N frequency bins, adjusts the channel estimate before generating the M complex weights in order to reduce channel mismatch caused by circuit mismatches.

21. The apparatus of claim 2 further comprising:

M D/As that each convert one of the M digital outputs of the IFFTs into one of a plurality of analog, baseband outputs;

M RF front ends that each modulate one of the analog baseband outputs from one of the M D/As into a radio frequency (RF) signal; and

M antennas that each transmit one of the RF signals from one of the M RF front ends.

22. The apparatus according to claim 21 in which the transmit beamformer further operates in a broadcast mode, during which broadcast mode one of the M antennas is used for transmission.

23. The apparatus according to claim 22, wherein during the broadcast mode only one of the M antennas is used for transmission.

24. The apparatus according to claim 22 wherein the one of the M antennas sends a Request-to-Send (RTS) signal.

25. The apparatus according to claim 24 wherein a new channel estimate is extracted from a Clear to Send (CTS) signal that is received in response to the sent RTS signal.

26. The apparatus according to claim 2 wherein a channel estimate aging threshold is set so that if the channel estimate becomes outdated, the outdated channel estimate is not used.

27. The apparatus according to claim 26 wherein, in response to the setting of the channel estimate aging threshold, an updated channel estimate is obtained from a Clear-to-Send (CTS) signal that is received in response to a sent Request to Send (RTS) signal.

28. The apparatus according to claim 21 wherein at least one of the M antennas transmits a CTS signal, thereby indicating to other transmitters to not transmit for a certain amount of time, thereby avoiding hidden node problems.

29. The apparatus according to claim 1 wherein the M signals are one of 802.11a and 802.11g signals.

30. The apparatus according to claim 1 wherein M equals 2.

31. The apparatus according to claim 1 wherein M equals 4.

32. The apparatus according to claim 1 wherein a separate antennae is used to transmit an RF signal corresponding to each of the M signals.

33. The apparatus according to claim 1 wherein a separate antennae is used to transmit an RF signal corresponding to the same frequency bin or frequency bins in each of the M signals.

34. The apparatus according to claim 1 wherein during a broadcast mode M antennas are used to transmit M RF signals that together correspond to a broadcast signal, and wherein one of the M antennas transmits an RF signal corresponding to a portion of that digital output that represents sub-carriers from some of the frequency bins, and each of the other of the M antennas transmits an RF signal corresponding to another portion of that digital output that represents sub-carriers from the other ones of the frequency bins.

35. The apparatus according to claim 1 further including M antennas, and wherein less than all of the M antennas are used to transmit RF signals, and wherein the less than all of the M antennas transmit on communication channels having a good transmit path.

36. The apparatus according to claim 1 wherein the array pattern is shaped to counter channel effects.

37. The apparatus according to claim 1 wherein the distinct array antenna pattern includes a plurality of distinct spatial patterns, one for each frequency bin.

38. A method of multiple antenna transmitter beamforming M digital output OFDM signals ("M signals") each including sub-carrier data in N frequency bins in a wideband wireless packetized communication network, wherein the M signals are each adapted for transmission onto different communication channels, and wherein each of the M signals are obtained from a same single digital signal , wherein N is a positive integer greater than 1, the method comprising:

phase steering the sub-carrier data in each of the N frequency bins for each of the M signals, thereby generating phase steered frequency data for each of the M signals; and converting the phase steered frequency data corresponding to each of the M signals using an Inverse Fast Fourier Transform (IFFT) to obtain the M signals, wherein M is an integer greater than or equal to 2, such that the M signals are adapted to shape a distinct array antenna pattern.

39. The method according to claim 1 further including the step of phase steering also includes weighting the sub-carrier data in each of the N frequency bins for each of the M signals, thereby generating phase steered and weighted frequency data for each of the M signals, and further including, prior to the step of phase steering, the steps of:

calculating M complex weights for each of the N frequency bins based on channel estimates of the different communication channels; and

wherein the step of phase steering includes applying the M complex weights to the sub-carrier data corresponding to each of the N frequency bins for each of the M signals to obtain the phase steered and weighted frequency data for each of the M signals.

40. The method according to claim 39 wherein the step of calculating includes using gain data in determining at least certain ones of the complex weights.

41. The method according to claim 39 wherein each IFFT sequentially processes the phase steered and weighted frequency data from each of the N frequency bins for the corresponding M signal.

42. The method according to claim 39 wherein the step of calculating includes using gain data in determining at least certain ones of the complex weights, and obtains the gain data from a receiver.

43. The method according to claim 42 further including the steps of transmitting the M signals, and receiving signals, and wherein the steps of transmitting and receiving share an antenna.

44. The method according to claim 42 further including the steps of transmitting the M signals, and receiving signals, and wherein the steps of transmitting and receiving share multiple antennas.

45. The method according to claim 39 wherein the step of calculating obtains the channel estimates from a receiver.

46. The method according to claim 45 further including the steps of transmitting the M signals, and receiving signals, and wherein the steps of transmitting and receiving share an antenna.

47. The method according to claim 45 further including the steps of transmitting the M signals, and receiving signals, and wherein the steps of transmitting and receiving share multiple antennas.

48. The method according to claim 45 wherein the channel estimates obtained from the receiver are for different channels received over a period of time.

49. The method according to claim 48 wherein the communication channels used correspond to those communication channels for which channel estimates are obtained.

50. The method according to claim 45 wherein the step of calculating obtains the channel estimate for a particular frequency bin for a particular communication channel.

51. The method according to claim 39 wherein at least some of the M complex weights for each of the N frequency bins are spectral flatness weights that assign constant power for each of the N frequency bins, thereby keeping spectral flatness across all of the N frequency bins for at least some of the M signals.

52. The method according to claim 39 wherein at least some of the M complex weights are obtained from gain-adjusted channel estimates and are normalized based upon Effective Isotrophic Radiated Power limit and per-chain power limit..

53. The method according to claim 39 wherein at least one of the M complex weights for each of the N frequency bins is a discretized complex weight having a lower resolution than full resolution.

54. The method according to claim 53 wherein the discretized complex weight is represented by a pair of 3-bit binary numbers.

55. The method according to claim 53 wherein each of the M weight blocks is a 12-bit x 3-bit multiplier.

56. The method according to claim 39 wherein the step of calculating, for each of the N frequency bins, adjusts the channel estimate before generating the M complex weights in order to reduce channel mismatch caused by circuit mismatches.

57. The method of claim 39 further comprising the steps of:

converting each one of the M digital outputs of the IFFTs into one of a plurality of analog, baseband outputs;

modulating each one of the analog baseband outputs into a radio frequency (RF) signal; and

transmit each one of the RF signals on one of M antennas.

58. The method according to claim 57 wherein there exists a broadcast mode, during which broadcast mode one of the M antennas is used for transmission.

59. The method according to claim 58, wherein during the broadcast mode only one of the M antennas is used for transmission.

60. The method according to claim 58 wherein the one of the M antennas sends a Request-to-Send (RTS) signal.

61. The method according to claim 60 wherein a new channel estimate is extracted from a Clear to Send (CTS) signal that is received in response to the sent RTS signal.

62. The method according to claim 39 wherein a channel estimate aging threshold is set so that if the channel estimate becomes outdated, the outdated channel estimate is not used.

63. The method according to claim 62 wherein, in response to the setting of the channel estimate aging threshold, an updated channel estimate is obtained from a Clear-to-Send (CTS) signal that is received in response to a sent Request to Send (RTS) signal.

64. The method according to claim 57 wherein at least one of the M antennas transmits a CTS signal, thereby indicating to other transmitters to not transmit for a certain amount of time, thereby avoiding hidden node problems.

65. The method according to claim 38 wherein the M signals are one of 802.11a and 802.11g signals.

66. The method according to claim 38 wherein M equals 2.

67. The method according to claim 38 wherein M equals 4.

68. The method according to claim 38 wherein during a broadcast mode M antennas are use to transmit M RF signals that together correspond to a broadcast signal, and wherein one of the M antennas transmits an RF signal corresponding to a portion of that digital output that represents sub-carriers from 1/M of the frequency bins, and each of the other of the M antennas transmits an RF signal corresponding to another portion of that digital output that represents sub-carriers from the each of the other 1/M of the frequency bins.

69. The method according to claim 38 further including M antennas, and wherein less than all of the M antennas are used to transmit RF signals, and wherein the less than all of the M antennas transmit on communication channels having a good transmit path.

70. The method according to claim 38 wherein the array pattern is shaped to counter channel effects.

71. The method according to claim 38 wherein the distinct array antenna pattern includes a plurality of distinct spatial patterns, one for each frequency bin.